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Multiphonon relaxation of optical excitations in CsCdBr3:Pr3+ and LiYF4:Nd3+ crystals

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Abstract

The technique of calculation of the n-phonon transition rates between electronic sublevels of impurity rare earth ions in dielectric crystals is developed in the case when n>2. The n-phonon transition probabilities are calculated according to the 1st and 2nd orders of perturbation theory. The Hamiltonian of the electron-phonon interaction is constructed in the framework of the exchange charge model and developed as series in relative displacements of the rare earth ion and ligands. The contribution of the lattice anharmonicity on the probabilities of n-phonon transitions is taken into account. On the basis of the developed technique, the nonradiative relaxation rates of 4G7/2 multiplet of Nd3+ ions in LiYF4:Nd3+crystal and 3P1 multiplet of Pr3+ ions in CsCdBr3:Pr3+ crystal were computed. The results of our calculations show that the 2nd order terms in the expressions for the probabilities studied here are comparable with, and in some cases prevail over the 1st order terms. An account of lattice anharmonicity in case of LiYF4:Nd3+ crystal substantially modifies the corresponding multiphonon relaxation rates. The calculated nonradiative relaxation rates for both crystals agree well with the experimental data.

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